Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Service Rules for the 698-746, 747-762 And 777-792 MHz Bands	)	WT Docket No. 06-150
Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling systems	)	CC Docket No. 94-102
Section 68.4(a) of the Commission's Rules Governing Hearing Aid-Compatible Telephones	)	WT Docket No. 01-309

Comments of Paul Milgrom and Karen Wrege

We submit these comments in response to the Notice of Proposed Rulemaking in the matter of Service Rules for the 698-746, 747-762 and 777-792 MHz bands ("Notice").[1] Paul Milgrom is the Shirley and Leonard Ely Professor of Humanities and Sciences in the Economics Department at Stanford University and director of the Market Design program at the Stanford Institute for Economic Policy Research (SIEPR). Karen Wrege was Deputy Chief of the Wireless Telecommunications Bureau, Spectrum Management Resources and Technologies Division until January 2006 and is now a consultant to international spectrum authorities and spectrum auction bidders in the US.

In the Notice, the Commission sought comment on possible changes to the Part 27 service rules governing wireless licenses in the 698-746, 747-762, and 777-792 MHz bands ("700 MHz Bands"). Among the changes that the

[1] In the Matter of Service Rules for the 698-746, 747-762 and 777-792 MHz Bands. *Notice of Proposed Rulemaking*, FCC 06-114, (Rel. August 10, 2006).

Commission sought comment on are possible revisions to the size of service areas for the unauctioned spectrum in the 700 MHz Band. Specifically, the Notice asked whether additional licenses should be created over service areas sizes other than Economic Area Groupings (EAGs), including over small areas such as the 734 Cellular Market Areas (CMAs) composed of Metropolitan Statistical Areas (MSAs) and Rural Service Areas (RSAs). The Commission also sought comment on the possibility of revising the size and pairings of the 20 MHz spectrum block in the Upper 700 MHz Band, (Block D). In addition, the Commission asked whether there should be any changes to the size and location of spectrum blocks in the Lower MHz Band.[2]

If the Commission decides that it is in the public interest to offer CMA license areas in the 700 MHz bands, we recommend that the boundaries of CMAs be adjusted so that each CMA is contained entirely within a single EA (or that the EAs be adjusted so that each EA comprises a set of CMAs). When offering various license sizes, there are practical advantages to having the smaller service areas (i.e. CMAs) fit perfectly into larger service area (i.e. EAs and EAGs) licenses. Suppose a bidder in an SMR auction wants to respond to changing prices by switching between an EA license and a collection of smaller CMA licenses that serves approximately the same geographic area. If the licenses match exactly, then the bidder can substitute exactly equivalent coverage and, if the associated bidding units continue to be set based on MHz-pops covered, than those will also match exactly, facilitating the substitution in either direction. The ability to substitute among collections of licenses is one of the central advantages of the simultaneous multiple round design, and so this change preserves and enhances that advantage. Similarly, if the Commission wanted to select a limited predetermined set of packages to offer in a combinatorial auction, it would be easy and natural to do so if the smaller service areas fit perfectly within the larger service areas. This modification to the service areas rules

[2] Id. at 2.

will allow bidders to compare prices and move between and among license areas and could make establishing packages of licenses less complex for the Commission and the bidders.

When determining the size of service areas and spectrum blocks in the 700 MHz bands, the Commission should also consider the possible usefulness of combinatorial bidding procedures in this context. In the original Notice of Proposed Rulemaking in the Matter of Service Rules for the 746-764 and 776-794 Bands ("Upper 700 MHz Bands"), the Commission requested comments on the merits of combinatorial auction procedures.[3] In that preceding and others that followed, bidders had several opportunities to comment on combinatorial bidding procedures. Some bidders support combinatorial bidding, while others are concerned about bidding complexity and overcoming the threshold problem.[4]

The majority of the commenters in the first Notice of Proposed Rulemaking in the Matter of Service Rules in the Upper 700 MHz Bands released on June 3, 1999 recommended larger geographic areas for these bands. One of the reasons why the Commission chose larger geographic areas for the Upper 700 MHz bands was because it was time constrained by statutory obligations.[5] Once those time constraints were lifted by Congress, the Commission began an extensive research and development effort to study various package bidding rules and alternative bidding languages.[6]

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[3] In the Matter Service Rules for the 746-764 and 776-794 Bands, *Notice of Proposed Rulemaking*, WT Docket No. 99-168, (Rel June 3, 1999) at 22.

[4] The threshold problem occurs when bidders for individual licenses are disadvantaged by the difficulty of raising their bids in a coordinated way to overcome the provisionally winning bid of a package bidder. This problem is most severe when there is little competition for the individual licenses and when the bidder's package is very large, for example consisting of all items in the auction. Smaller bidders, without the pressure of competition, must be able to each incrementally increase bids that are already the highest bids for their individual licenses so that, collectively, they can overcome the bid price of the large package bid.

[5] In the Matter of Service Rules for the 746-794 MHz Bands, and Revisions to Part 27 of the Commission's rules, *First Report and Order* , WT Docket No. 99-168, (Rel January 7, 2000) at 57.

[6] The Commission's auction software contractor Computech, Inc. (Bethesda, MD) subcontracted with Decisive Analytics, Inc. (Arlington, VA), an operations research and

Beginning in 2003, the Commission developed the Integrated Spectrum Auction System ("ISAS") that was designed to allow the Commission to adapt its auction system based on the unique characteristics of the spectrum offering. The system includes an auction set up module that allows the Commission to choose whether the spectrum will be auctioned using SMR or SMR-PB formats. ISAS uses an off-the-shelf optimization program (CPLEX) for the winner determination problem that can be easily adapted as the auction rules evolve. The system was first used in Auction No. 60 in July of 2005 (in which 5 CMA licenses were auctioned in the Lower 700 MHz band.) Since its introduction, the system was adapted to auction mutually exclusive band plans in Auction No. 65 (800-MHz Air to Ground Radiotelephone Service) and was modified again for Auction No. 66 (Advanced Wireless Service) to withhold certain information on bidder interests, bids and bidder identities that typically have been revealed prior to and during auction events.[7]

The Commission has spent considerable time, effort and resources studying and testing the relative merits and shortcomings of various combinatorial bidding procedures. Most recently, the Commission contracted with Jacob K. Georee, Charles A. Holt and John O. Ledyard to conduct laboratory experiments to compare simultaneous, multi-round auctions and simultaneous multi-round auctions with package bidding ("SMR-PB"). The test results concluded that with high complementarities, packaging bidding raises efficiency.[8] Since there are likely to be high complementarities in the 700 MHz bands, the Commission should consider the use of combinatorial

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development company that customized the CPLEX software (ILOG, Inc., Mountain View, CA) for FCC spectrum auctions.

[7] Limiting information was first introduced by the Wireless Telecommunications Bureau ("Bureau") for the AWS auction. The Bureau decided that if the eligibility ratio before the auction was less than 3, the Bureau would withhold certain information before and during the auction.

[8] Jacob K. Goeree, Charles A. Holt, and John Ledyard. An Experimental Comparison of the FCC's Combinatorial and Non-Combinatorial Simultaneous Multiple round Auctions. July 12, 2006. Page 2.

bidding procedures. Because bidders will need time to fully understand a new combinatorial auction design, it is important to begin the discussion in this preceding and not wait for the Public Notice announcing the auction.[9] We recommend that the Commission schedule a Public Forum to present and discuss the research and testing that it has done in this area and to solicit industry feedback about simpler package auction designs.

It is well established that bidders in the Commission's standard simultaneous multiple round auction can face an "exposure problem," according to which the bidder risks acquiring some licenses without acquiring a sufficient package to establish a viable business. This problem has been cited repeatedly in consultants' reports to the Commission[10] as well as in the academic literature.[11] Combinatorial bidding can enhance efficiency and revenues by eliminating that risk and so encouraging competition among bidders with very different business plans, allowing each to bid for the individual licenses or packages that fit best with their plans.

The Commission's SMR-PB auction format allows each bidder to have at most a single winning bid,[12] so that in order to win any particular license combination, the bidder must have placed a package bid on that license or specific group of licenses.[13] The SMR-PB therefore could require bidders to enumerate every package that they might at some point consider profitable. It is considered so complex by the Wireless Telecommunications Bureau

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[9] The Wireless Telecommunications Bureau ("Bureau") often waits to seek comments on bidding procedures until release of the Public Notice announcing the auction event.

[10] Three such reports to the FCC include the 1997 report by Charles River Associates and Market Design Inc, "Package Bidding for Spectrum Licenses," the 2000 report by Cybernomics, "An Experimental Comparison of the Simultaneous Multiple Round Auction and the CRA Combinatorial Auction," and the 2006 report by Goeree, Holt and Ledyard, "An Experimental Comparison of the FCC's Combinatorial and Non-Combinatorial Simultaneous Multiple Round Auctions."

[11] A book of essays discussing this and other issues surrounding combinatorial bidding is: Combinatorial Auctions edited by Peter Cramton, Yoav Shoham, and Richard Steinberg, Cambridge: MIT Press, 2005.

[12] In computer language this is referred to as XOR

[13] *Auction of Advanced Wireless Services Licenses Scheduled for June 29, 2006 Comment Public Notice.* Report No. AUC-06-66-B, AU Docket No. 06-30 (WTB release April 12, 2006) ("Public Notice").

("Wireless Bureau") that in the AWS Auction Procedures Public Notice it noted that it is not practical or desirable to conduct a single SMR-PB auction with all 1,122 AWS licenses.[14] For the 700 MHz bands, it is useful to consider alternative combinatorial auction designs that meet bidders' most critical needs while avoiding unnecessary complexity.

Our goal is to propose a package auction with the following attributes:

(1) The auction promotes an efficient outcome.

(2) The auction is fair to all bidders.

(3) The auction ends in a reasonable amount of time.

(4) The auction has limited transaction costs, i.e. the rules are not so difficult or the bidding so complicated that a straightforward bidder finds it difficult to participate.

(5) The auction promotes price discovery for individual licenses to the extent possible.

(6) The auction is computationally feasible, i.e. the auctioneer can calculate the provisionally winning bids and next round prices and bidders are able to determine their most profitable packages in a reasonable period of time.

(7) The auction is scalable to be able to include 1000 or more licenses of small service areas (CMAs).

To achieve these objectives, we propose a variant of the Commission's current SMR design, but with one key change: allow bidders to submit a limited set of package bids to mitigate the exposure problem while keeping the auction simple and transparent. Both the academic literature[15] and the FCC's consultants' reports[16] make it clear that there are only a limited

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[14] *Auction of Advanced Wireless Services Licenses Scheduled for June 29, 2006 Procedures Public Notice.* Report No. AUC-06-66-A, AU Docket No. 06-30 (WTB release February 28, 2006) ("Public Notice").

[15] Rothkopf, Michael, Aleksander Pekec and Ronald Harstad (1998), "Computationally Manageable Combinatorial Auctions," Management Science **44**: 1131-1147.

[16] Charles River Associates and Market Design, Inc (1997), "Package Bidding for Spectrum Licenses." Report to the U.S. Federal Communications Commission.

number of practical ways to restrict packages that achieve this simplicity, of which two merit the FCC's special attention.

The first possibility is for packages to be structured hierarchically. For example, EA licenses may be regarded as packages of CMA licenses, REA licenses may be regarded as packages of EA licenses, and national licenses may be regarded as packages of REA licenses, with bidding permitted for the individual CMA licenses as well as for the EA, REA and national packages. Solving the winner determination problem with this structure is an easy one computationally and proceeds in the following quite transparent fashion. First, one determines the maximum bid or collection of bids for each EA area. Since there can be only one winning package bid for each EA,[17] this is a simple computation. Second, one uses the winning EA bids to determine the maximum bid or collection for each REA. Finally, one uses the winning REA bids to determine the maximum bid or collection of bids for the entire nation. These are easy problems and so can be scaled to bidding for a thousand or more licenses.

The second possibility is for packages to be required to consist entirely of CMA licenses within predefined non-overlapping sets of licenses and to be further restricted to consist of licenses covering more than 50% of the bidding units in any of the specified areas. For example, the allowed packages might consist of all sets of licenses covering more than 50% of the bidding units in a particular spectrum band within one particular EA. Alternatively, the EA restriction might be replaced by an REA restriction or by the restriction that the licenses cover more than 50% of the bidding units in a particular band on

[17] The winner determination problem is complex in combinatorial auctions when one is forced to consider various combinations of packages that might be part of the winning set and when the number of potential combinations is too large to enumerate in a practical way. The two variations recommended here make the winner determination problem easy by eliminating the need to evaluate combinations of packages to determine the set of winning bids.

the entire mainland US, depending on the bidders' demands.[18] Once again, this package structure makes the problem of determining the winning bids a computationally easy and transparent one, because only one package bid can be winning for each specified set of licenses.

Since there are no overlapping packages by a single bidder in either of these structures, computing activity for packages is simply the sum of the bidding units of each license for which a bid is placed, either as an individual license or as part of a package. Similarly, the minimum acceptable bid ("MAB") calculation for packages can be the sum of the MABs of the individual licenses.

If either of these package structures is adopted, the existing FCC auction procedure could be used to guide the bidding. This procedure includes a means of specifying individual prices for licenses. To avoid advantaging package bidders over small bidders who might prefer to bid for individual licenses, we recommend the adoption of a surcharge or premium of 25% to be added to the payments for winning package bids. This surcharge substantially mitigates the threshold problem, avoids creating an unfair advantage for package bidders over bidders for individual licenses, and avoids encouraging large bidders from bidding on packages merely to gain a strategic advantage over smaller bidders.

The auction design that we describe does not disadvantage package bidders relative to the current simultaneous multiple round design, because no bidder is required to make a package bid. If no bidder does make such a bid, then the auction may run in much the same way as the current simultaneous multiple round auction. The proposed package bidding feature adds an option, not a requirement, and allows bidders to participate effectively even in the face of severe exposure problems. It promotes the

[18] The areas must not overlap, so this rule does not allow the specified areas to include both packages covering an EA and larger ones covering an REA in the same band, nor does it allow an EA or REA and a national license in the same spectrum band.

objectives of efficiency, fairness, scalability, computational feasibility and individual license pricing, and, with a proper implementation, can also achieve reasonable speed in achieving its outcome. Such an auction can substantially improve upon the current simultaneous multiple round design when the exposure problem is a serious one. We commend it for your consideration.